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[पी : 7]

गणना द्वारा उष्मीय मान ज्ञात करना

(पहला पुनरीक्षण)

Indian Standard

METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS

[P : 7]

DETERMINATION OF CALORIFIC VALUE BY CALCULATION

(First Revision)

ICS 75.080

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

November 2004

Price Group 3

Methods of Measurement and Test for Petroleum, Petroleum Products and Lubricants
Sectional Committee, PCD 1

FOREWORD

This Indian Standard [P : 7] (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Methods of Measurement and Test for Petroleum, Petroleum Products and Lubricants Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

This test method was first published in 1960. In this standard scope as well as terminology have been modified. Summary of test method, significance and use have been included. Presentation of calculation has been updated. Considerable assistance has been derived from ASTM D 4868 'Standard test method for estimation of net and gross heat of combustion of burner and diesel fuels' for formulation of this test method.

The composition of the Committee responsible for formulation of this standard is given in Annex A.

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS

[P : 7]

DETERMINATION OF CALORIFIC VALUE BY CALCULATION

(First Revision)

1 SCOPE

1.1 This method is intended for the determination of the calorific value, gross or net, of petroleum fuels by calculation from the fuel density, sulphur, water and ash content.

1.2 This method shall be used only as a routine alternate method for the quick estimation of calorific value, and for accurate determination and in case of dispute the method prescribed in IS 1448 [P : 6] shall be adopted.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1448	Methods of test for petroleum and its products
[P : 4] : 1984	Ash, sulphated ash and water soluble ash (*second revision*)
[P : 6] : 1984	Heat of combustion of liquid hydrocarbon fuels by Bomb calorimeter method (*first revision*)
[P : 33] : 1991	Sulphur by Bomb method (*second revision*)
[P : 34] : 1979	Determination of sulphur in petroleum products (Lamp method) (*second revision*)
[P : 40] : 1987	Water by distillation (*third revision*)

3 TERMINOLOGY

For the purpose of this test method, the following definitions shall apply.

3.1 Gross Calorific Value — The gross calorific value of a fuel at constant volume is the number of heat units which would be liberated when unit weight of fuel is burnt at constant volume in oxygen saturated with water vapour, the original and final materials being at 15°C, the residual products being carbon dioxide, sulphur dioxide, nitrogen and water, the water other than that originally present as vapour, being in the liquid state.

3.2 Net Calorific Value — The net calorific value of a fuel is the number of heat units which would be liberated when unit weight of the fuel is burned in oxygen saturated with water vapour, the original and final materials being at 15°C and the residual products being carbon dioxide and nitrogen. This value may be expressed either at constant pressure or constant volume.

3.3 Units of Measurement — The units of measurement employed in this method are the calorie and the British Thermal Unit, defined as follows:

1 calorie at 15°C = 4.185 5 joule
1 calorie = 4.186 8 joule (exactly)
1 Btu/lb°F = 4.186 8 joule/g°C (exactly)

3.4 Most petroleum products consist essentially of a large number of different hydrocarbons which are so nearly alike physically that a mixture of them exhibits a thermodynamic behaviour somewhat analogous to that shown by a mixture of isotopes. It has been established experimentally that many of these properties, including the calorific value, are closely related to the density of the liquid which may easily be determined using a hydrometer. The relationship affords a very useful means of computing the calorific value of petroleum and its products.

The relation between total heat of combustion at constant volume and specific gravity for pure hydrocarbons, water- , ash- and sulphur-free, found in petroleum is given by:

$$q_v = 12\,400 - 2\,100 d^2$$

where

q = calorific value at constant volume in cal/g, and

d = specific gravity at 15.56°C/15.56°C.

The calorific value at constant pressure is given by:

$$q_p = q_v - H\,(WL - C)\,0.01$$

where

q_p = calorific value at constant pressure, in cal/g;

q_v = calorific value at constant volume, in cal/g;

H = hydrocarbon content, percent by weight, in the material, calculated from the approximate relation:

$$H = 26 - 15\,d$$

d = the specific gravity at 15.56°C/15.56°C;

W = number of grams of water formed from 1 g of hydrogen, equal to 9;

L = latent heat of vaporization of water at 20°C equal to 585; and

C = correction to take into account the change in volume from initial to final products, equal to 220.

The calorific values of petroleum and its product which are mixtures of hydrocarbons containing certain impurities in the form of water, ash and sulphur are obtained from the relations given in 7.

4 SUMMARY OF TEST METHOD

The density, sulphur, water and ash content of the sample are determined by experimental test methods. The heat of combustion is calculated using the values obtained by these test methods based on reported correlation.

5 SIGNIFICANCE AND USE

This test method is intended for use in case where an experimental determination of heat of combustion is not available and can not be made, conveniently and where an estimate is considered satisfactory. It is not intended as a substitute for experimental measurement of heat of combustion.

6 METHOD

6.1 Experimental Determination

Determine the water content of the material by the method given in IS 1448 [P : 40], ash content by the method given in IS 1448 [P : 4] and sulphur content by the method given in IS 1448 [P : 33] or IS 1448 [P : 34].

7 CALCULATION

7.1 Calculate the heat of combustion of the fuel corrected for sulphur, water and ash content in accordance with the following equations:

$$Q_v\,(\text{Gross}) = q_v - 0.01\,q_v\,(W + A + S) + X(S) \quad \dots (1)$$

$$Q_p\,(\text{Net}) = q_p - 0.1\,q_p\,(W + A + S) + X(S) - Y(W) \dots (2)$$

where

Q_v = corrected calorific value of the material at constant volume, in cal/g;

q_v = calorific value at constant volume, in cal/g (12 400-2 100 d_2);

d = specific gravity at 15.56°C/15.56°C;

W = percent, water by mass, of the material (W = number of grams of water formed for 1 g of hydrogen equal to 9);

A = percent, ash by mass, of the material;

S = percent, sulphur by mass, of the material;

X = correction factor equal to 22.5 when Q is expressed, in cal/g;

Q_p = corrected calorific value of material at constant pressure in cal/g;

q_p = calorific value at constant pressure, in cal/g [$q_p = q_v - H\,(WL - C)\,0.01$];

H = hydrogen content, percent by mass (H = 26–15 d);

Y = correction factor, equal to 5.85 when Q is expressed, in cal/g;

L = latent heat of vaporization of water at 20°C, equal to 585; and

C = corrections to take into account the change in volume from initial to final products, equal to 220.

7.2 Increase the values given in Table 1 by about one percent to get the calorific value of the vapour in the case of volatile petroleum products.

8 REPORT

Report the result as the estimated gross or net to the nearest whole number.

9 PRECISION

The precision of the estimated value will be dependent upon the accuracy of the determined density, sulphur, water and ash contents.

Repeatability	*Reproducibility*
75 cal/g	150 cal/g

Table 1 Heat of Combustion of Crude Oils, Fuel Oils, Kerosine and Volatile Petroleum Products

(*Clause* 7.2)

Gravity		Density at 15°C g/ml	Total Heat of Combustion at Constant Volume cal/g	Net Heat of Combustion at Constant Pressure cal/g
Degree API	Specific at 15.56°C/15.56°C			
(1)	(2)	(3)	(4)	(5)
10	1.000 0	0.999 4	10 300	9 740
11	0.993 0	0.992 4	10 330	9 770
12	0.986 1	0.985 5	10 360	9 790
13	0.979 2	0.978 7	10 390	9 810
14	0.972 5	0.971 9	10 410	9 840
15	0.965 9	0.965 3	10 440	9 860
16	0.959 3	0.958 8	10 470	9 880
17	0.952 9	0.952 3	10 490	9 900
18	0.946 5	0.945 9	10 520	9 920
19	0.940 2	0.939 7	10 540	9 940
20	0.934 0	0.933 5	10 570	9 960
21	0.927 9	0.927 3	10 590	9 980
22	0.921 8	0.921 3	10 620	10 000
23	0.915 9	0.915 3	10 640	10 020
24	0.910 0	0.909 5	10 660	10 040
25	0.904 2	0.903 7	10 680	10 050
26	0.898 4	0.897 9	10 710	10 070
27	0.892 7	0.892 3	10 730	10 090
28	0.887 1	0.886 7	10 750	10 110
29	0.881 6	0.881 1	10 770	10 120
30	0.876 2	0.875 7	10 790	10 140
31	0.870 8	0.870 3	10 810	10 150
32	0.865 4	0.865 0	10 830	10 170
33	0.860 2	0.859 7	10 850	10 180
34	0.855 0	0.854 5	10 860	10 200
35	0.849 9	0.849 4	10 860	10 210
36	0.844 8	0.844 3	10 900	10 230
37	0.839 8	0.839 3	10 920	10 240
38	0.834 8	0.834 4	10 940	10 260
39	0.829 9	0.829 5	10 950	10 270
40	0.825 1	0.824 7	10 970	10 280
41	0.820 3	0.819 9	10 990	10 300
42	0.815 6	0.815 6	11 000	10 310
43	0.810 9	0.810 5	11 020	10 320
44	0.806 3	0.805 9	11 030	10 330
45	0.801 7	0.801 3	11 050	10 340
46	0.797 2	0.796 8	11 070	10 363
47	0.792 7	0.792 4	11 080	10 373
48	0.788 3	0.788 0	11 100	10 380
49	0.783 9	0.783 6	11 110	10 390
50	0.779 6	0.779 3	11 120	10 400
51	0.775 3	0.775 0	11 140	10 440
52	0.771 1	0.770 8	11 150	10 420
53	0.766 9	0.766 6	11 160	10 430
54	0.762 8	0.762 5	11 180	10 440
55	0.758 7	0.758 4	11 190	10 450
56	0.754 7	0.754 4	11 200	10 460
57	0.750 7	0.750 4	11 220	10 470
58	0.746 7	0.746 4	11 230	10 480
59	0.742 8	0.742 5	11 240	10 490

Table 1 (*Concluded*)

Gravity		Density at 15°C g/ml	Total Heat of Combustion at Constant Volume cal/g	Net Heat of Combustion at Constant Pressure cal/g
Degree API	Specific at 15.56°C/15.56°C			
(1)	(2)	(3)	(4)	(5)
60	0.738 9	0.738 7	11 250	10 500
61	0.735 1	0.735 8	11 270	10 510
62	0.731 3	0.731 0	11 280	10 520
63	0.727 5	0.727 3	11 290	10 530
64	0.723 8	0.723 6	11 300	10 540
65	0.720 1	0.719 9	11 310	10 540
66	0.716 5	0.716 2	11 320	10 550
67	0.712 8	0.712 6	11 330	10 560
68	0.709 3	0.709 1	11 340	10 570
69	0.705 7	0.705 5	11 350	10 580
70	0.702 2	0.702 0	11 360	10 580
72	0.695 3	0.695 1	11 380	10 600
74	0.688 6	0.688 4	11 400	10 610
76	0.681 9	0.681 8	11 420	10 630
78	0.675 7	0.675 3	11 440	10 640
80	0.669 0	0.668 9	11 460	10 650
82	0.662 8	0.663 6	11 480	10 670
84	0.656 6	0.656 5	11 490	10 680
86	0.650 6	0.650 5	11 510	10 690
88	0.644 6	0.644 6	11 530	10 700
90	0.638 8	0.638 7	11 540	10 710
91	0.633 1	0.633 0	11 560	10 720
94	0.627 5	0.627 4	11 570	10 740
96	0.622 0	0.621 9	11 590	10 750
98	0.616 6	0.616 5	11 600	10 760
100	0.611 2	0.611 2	11 620	10 770
105	0.598 3	0.598 3	11 650	10 790
110	0.585 9	0.585 9	11 680	10 810
115	0.574 0	0.574 1	11 710	10 830
120	0.562 6	0.562 7	11 740	10 850
125	0.551 7	0.551 9	11 760	10 860
130	0.541 1	0.541 3	11 790	10 880
135	0.531 0	0.531 2	11 810	10 900
140	0.521 2	0.521 5	11 830	10 910
145	0.511 8	0.512 1	11 850	10 920

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Methods of Measurement and Test for Petroleum, Petroleum Products and Lubricants Sectional Committee, PCD 1

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Headquarters :

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002
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Telegrams : Manaksanstha
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Regional Offices :		Telephone
Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110 002	2323 7617 2323 3841
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